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Abstract
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Evaluation of a Byproduct from Hydrolyzed Porcine Small Intestines as an Ingredient in Pig Starters

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Summary and Implications

Partial replacement of dried whey with dried hydrolysate of pig intestines resulted in a delayed positive growth performance response in three experiments. In weeks three and four, average daily gain and average daily feed intake were increased an average of 23.9 and 17.6%, respectively, by feeding intestinal hydrolysate in weeks one and two. The active component(s) in the product may speed the maturation of the pig's ability to digest and/or assimilate nutrients.

Introduction

This research project was conducted to study the feeding value for weanling pigs of dried products prepared from the residue of hydrolyzed porcine small intestines remaining after extraction of heparin. The products contain protein of high quality and have a high mineral content, being particularly rich in sodium. The overall goal of the project was to find a value-added market for the residue, which until this time has been utilized as fertilizer for row crops.

Materials and Methods

General

Pigs in all four experiments were weaned and immediately placed on experimental diets. The experiments lasted for 28 days, and growth performance is reported for weekly and cumulative periods.

Pigs were housed in groups in 4 x 4 ft. raised-deck pens with woven-wire floors. Each pen was equipped with a 1 x 4 ft. heat pad, a stainless steel self-feeder, and a nipple drinker. The heat pads supplied supplemental heat for the first two weeks. Room temperature was maintained at 75±5ºF.

Pigs were allotted at random on the basis of initial weight and litter to blocks of pens. Contiguous pens within blocks were randomly assigned to treatments. Data were analyzed by analysis of variance using randomized block designs. In Experiment 4, pens within blocks were balanced for sex.

Responses to treatments were evaluated for growth rate and feed efficiency. Pigs were observed daily for general health. Diarrhea scores were taken daily on a pen basis, with scores of 1=normal, 2=slight, 3=moderate, and 4=severe.

Experiment 1

Two dietary treatments were compared with each treatment fed to ten pens of four pigs each. The treatments were as follows: 1) a control diet (Table 1) containing 20% dried whey, corn, and soybean meal; and 2) an experimental diet in which 5% drum-dried intestinal hydrolysate replaced an equal amount of soybean meal. No sodium chloride was added to the experimental diet because of the large amount of sodium chloride contributed by the intestinal hydrolysate.

Experiment 2

In this experiment, the intestinal byproducts plus lactose replaced dried whey in the control diet (Table 1). The rationale for this substitution was that both dried whey and intestinal hydrolysate contain high-quality proteins and have relatively high sodium contents. The variable ingredients in the four treatment diets are outlined in Table 2. Diets had equal concentrations of lactose and lysine. One intestinal hydrolysate was a commercially available product (Protein Plus, RDE Inc., Crystal Lake, Illinois) fed at 5% of the diet. The other was an experimental hydrolysate flash-dried on soybean hulls. The latter product was fed at 6.13 and 12.26% of the diet.

Each treatment was fed to six pens of pigs. Each pen contained six pigs. The treatment diets were fed for the first two weeks, and then all groups were fed a common diet (Table 1) for an additional two weeks.

Experiment 3

In this experiment, a control diet (Table 1) containing 25% dried whey was compared with three diets containing three different experimental hydrolysate products dried on soybean hulls (6%) and one diet containing 5% spray-dried plasma (AP920). The variable ingredients in the diets are outlined in Table 3. Diets had equal concentrations of lactose, lysine, and methionine.

Experiment 4

The intestinal hydrolysate used in the experiment was a newly developed commercial product, Porcine Solubles, manufactured by Nutra-Flo Co., P.O. Box 2334, Sioux City, Iowa. This product is an intestinal hydrolysate dried on soybean hulls. The treatment diets were similar to those used in previous experiments. The product was included at 6% of the diet and replaced dried whey in the control diet (Table 1). Lactose levels remained constant across treatments. Treatments were: 1) control, 2) 6% Porcine Solubles for two weeks, and 3) 6% Porcine Solubles for four weeks. Each treatment was applied to seven pens of four pigs each.

Results and Discussion

Experiment 1

The general growth performance (Table 4) of the pigs in this experiment was excellent. During the second week, pigs fed the diet containing 5% hydrolysate gained body weight more rapidly and efficiently than those fed the control diet. However, during the first week, during the 14- to 20-day

period, and for the overall feeding period, growth performance did not differ between treatment groups.

The body weight variation of pigs within pens was calculated and expressed as coefficients of variation. There was no indication that one or the other treatment led to more change in variation during the experiment.

These research data indicate that the mucosa hydrolysate product can be included at 5% of the diet as a replacement for soybean meal. At this concentration, growth performance of pigs was not different from that of pigs fed the control diet.

It may be possible to utilize the byproduct at concentrations greater than 5% of the diet. These greater concentrations, however, need to be confirmed through feeding trials.

High concentrations of byproduct might lower the energy and/or raise the sodium concentration to a point at which growth performance would be depressed.

Experiment 2

Growth performance data is summarized in Table 5. Each value in Table 5 is the mean of pigs in six pens. The treatments are coded as follows: 1) dried whey, 2) 5% Protein Plus, 3) 6.13% experimental hydrolysate, and 4) 12.26% experimental hydrolysate. The columns under Significance refer to L=linear and Q=quadratic comparisons among treatments 1, 3, and 4, and a comparison between treatments 2 and 3. Growth performance is expressed for each week and for cumulative weeks: C2=weeks 1 and 2; C3=weeks 1, 2, and 3; and C4=weeks 1, 2, 3, and 4.

During week one, the high level of inclusion of experimental hydrolysate decreased feed intake and average daily gain. In the second week, however, the low level of experimental hydrolysate stimulated feed intake, average daily gain, and feed efficiency. In weeks three and four, when all pigs were fed a common diet, pigs that previously had been fed Protein Plus or experimental hydrolysate outperformed the pigs fed the control diet. They ate more feed and grew faster and more efficiently. These latter results suggest a carry-over effect. This response is difficult to explain. It may be that pigs treated with intestinal hydrolysates have healthier or physiologically more developed gastrointestinal systems.

Because the responses were highly significant but were difficult to explain on a nutritional or physiological basis, the next experiment was conducted to verify the findings.

Experiment 3

Responses to treatments are reported in Table 6 for average daily gain (ADG), average daily feed intake (ADFI), and gain:feed ratio (G/F). Each response is reported for weekly periods and for cumulative (C) periods. Additionally, average daily pen diarrhea scores over the first two weeks are reported.

During the first week, pigs fed the diet containing spray-dried plasma consumed more feed and gained weight faster and more efficiently than pigs fed other diets. Also, pigs fed diet 2 grew slower than those fed diet 4 and were less efficient than pigs fed diet 3. In the second week, pigs fed plasma (diet 5) consumed more feed but did not gain weight faster or more efficiently than pigs fed the other diets. In the third week, when all pigs were fed a common diet, there was a trend for pigs that had previously consumed diets containing experimental hydrolysates to consume more feed and gain weight more rapidly than pigs that previously had been fed the control and plasma diets. In the fourth week, these trends continued for feed intake and rate of gain, and the pigs fed diet 4 gained weight significantly faster than pigs previously fed the control and plasma diets.

The diarrhea scores averaged over the two-week period in which experimental diets were fed indicate that diarrhea was reduced by feeding spray-dried plasma. This response has been observed in previous experiments. It is probably attributable to the immunoglobins present in spray-dried plasma.

The growth responses in weeks three and four to small intestine hydrolysates that had been fed in weeks one and two were of lower magnitude in this experiment than in experiment 2. However, positive responses were still evident. At present, the explanation for these responses is not known.

In general, the pigs in this experiment had a high incidence of diarrhea, and mortality was higher than normal for our production unit. Six pigs died during the course of the experiment. During the experiment, we observed an outbreak of pseudorabies in the herd. Serology revealed that sows in the breeding herd and pigs in this experiment had become infected. The growing-finishing pigs and the pigs in our intensive research building had not become infected. It is not clear whether the pseudorabies infection had any effect on treatment responses.

Experiment 4

The treatment responses for rate of daily gain (ADG), daily feed intake (ADFI), and gain:feed ratio (G/F) are reported in Table 7. Again, each response is reported by week and for cumulative periods. As in the previous experiments, partial replacement of dried whey with intestinal hydrolysate did not improve performance of the weanling pigs in the first two weeks after weaning; but in weeks three and four, pigs that had been fed intestinal hydrolysate (treatment 2) and those that continued to be fed the product (treatment 3) grew more rapidly and consumed more feed than those fed the control diets (Treatment 1).

General Discussion

Positive performance responses have occurred in three of three experiments in which porcine intestinal hydrolysate partially replaced dried whey in weanling pig diets. In all experiments, there was a lag time before the responses appeared, and the responses persisted after the product was removed from the diet. This pattern of response suggests that the active ingredient(s) causing the positive response may be acting to speed the maturation of the pig's ability to digest or assimilate nutrients.

Table 1. Experimental control diets.

Ingredient, %	Exp 1 weeks 1-4	Exp 2 weeks 1&2	Exp 2+3 weeks 3&4	Exp 3 weeks 1&2	Exp 4 weeks 1&2	Exp 4 weeks 3&4
Corn	46.31	36.00	55.79	39.86	36.83	49.80
Soybean meal	27.00	27.10	29.10	27.87	30.90	27.60
Dried whey	20.00	26.20	10.00	25.00	25.00	15.00
Corn starch	-	5.20	-	1.53	1.50	1.50
Soybean oil	3.00	2.00	1.00	2.00	2.00	2.00
L-Lysine·HCl	.10	.20	.20	.18	.20	.20
DL-Methionine	-	.10	-	.10	.14	.11
Vit/min/add	3.59	3.20	3.91	3.46	3.43	3.79
Calculated analysis (%):						
Lysine	1.21	1.30	1.25	1.30	1.40	1.25
Methionine + cystine	.66	.77	.68	.77	.84	.75
Calcium	.80	.80	.80	.80	.80	.80
Phosphorus	.70	.70	.70	.70	.70	.70
Sodium	.36	.34	.25	.43	.43	.30

Table 2. Variable ingredients in experiment 2 diets.

	Diet number[a]			
Ingredient	1	2	3	4
Dried whey	26.20	13.10	13.10	0
Lactose	0	9.17	9.17	18.34
Corn starch	5.20	3.60	2.59	0
Protein Plus	0	5.00	0	0
Experimental hydrolysate	0	0	6.13	12.26

[a]Lactose and lysine concentrations were equal across treatments.

Table 3. Variable ingredients in experiment 3 diets.

	Diet number[a]				
Ingredient	1	5	3	4	5
Dried whey	25	10	10	10	0
Lactose	0	10.5	10.5	10.5	17.5
L-Lysine·HCl	.18	.18	.18	.18	0
DL-Methionine	.10	.13	.13	.13	.15
Experimental hydrolysate-1	0	6	0	0	0
Experimental hydrolysate-2	0	0	6	0	0
Experimental hydrolysate-3	0	0	0	6	0
Plasma, AP920	0	0	0	0	5.00
Starch	1.53	0	0	0	4.16

[a]Lactose, lysine, and methionine concentrations were equal across treatments.

Table 4. Growth performance – Experiment 1.[a]

		Treatments			
Item	Week[b]	Control	5% Hydrolysate	CV, %	P<
ADG, lb./day	1	.58	.57	12.6	.57
	2	.83	.99	13.6	.02
	3	1.20	1.16	14.0	.57
	C2	.71	.78	12.0	.10
	C3	.85	.89	11.6	.42
ADFI, lb./day	1	.77	.70	11.8	.12
	2	1.37	1.38	10.5	.91
	3	1.93	2.02	11.6	.42
	C2	1.07	1.04	10.6	.58
	C3	1.33	1.33	10.6	.93
G/F	1	.745	.801	9.5	.12
	2	.610	.723	12.5	.01
	3	.623	.575	7.6	.04
	C2	.657	.750	9.1	.01
	C3	.642	.670	6.6	.18

[a]Initial weight 14.4 lb.; final weight 31.8 lb.; each value is the mean of ten pens, each containing four pigs.
[b]C2 and C3 indicate cumulative two- and three-week responses, respectively.

1. **Table 5. Growth performance – experiment 2.**[a]

Item	Week[c]	Treatment no.[b] 1	2	3	4	Significance, P> L	Q	2 vs. 3	CV
ADG, lb./day	1	.18	.17	.17	.10	.09	.35	.98	45.1
	2	.47	.66	.86	.56	.95	.0009	.03	22.0
	3	.68	.96	1.07	.99	.005	.010	.26	17.6
	4	.91	1.15	1.28	1.34	.0001	.05	.14	12.1
	C2	.37	.42	.52	.33	.40	.0002	.02	16.9
	C3	.47	.60	.70	.55	.09	.0002	.04	13.5
	C4	.60	.74	.84	.75	.002	.0004	.03	10.8
ADFI, lb./day	1	.37	.36	.34	.25	.002	.41	.42	16.7
	2	.85	.96	1.04	.84	.87	.001	.16	10.8
	3	1.27	1.56	1.81	1.54	.02	.0003	.03	11.4
	4	1.62	1.98	2.23	2.23	.0006	.003	.05	10.3
	C2	.61	.66	.69	.54	.09	.002	.41	9.7
	C3	.83	.96	1.06	.88	.36	.0002	.06	9.4
	C4	1.03	1.21	1.35	1.19	.02	.0003	.04	8.8
G/F	1	.405	.470	.454	.390	.88	.51	.88	39.5
	2	.660	.675	.826	.664	.95	.01	.04	16.0
	3	.525	.617	.590	.635	.009	.75	.48	10.8
	4	.560	.578	.570	.632	.002	.15	.69	5.9
	C2	.596	.626	.745	.598	.98	.0007	.01	10.8
	C3	.562	.621	.658	.619	.05	.01	.18	7.5
	C4	.560	.603	.622	.627	.0008	.05	.25	4.6

[a]Initial weight 14.8 lb.; final weight 29.1 lb.; each value is the mean of six pens, each containing five pigs.
[b]Refer to Table 2 for treatment description.
[c]C2, C3, and C4 indicate cumulative two-, three-, and four-week responses, respectively.

Table 6. Growth performance and diarrhea scores – experiment 3.[a]

Item	Week[c]	Treatment no.[b] 1	2	3	4	5	CV
ADG, lb./day	1	.10^{xy}	.06^{x}	.13^{xy}	.15^{y}	.29^{z}	45.7
	2	.60	.59	.61	.59	.72	20.8
	3	.97	1.08	1.05	1.05	.89	15.6
	4	1.06^{x}	1.23^{xy}	1.18^{xy}	1.40^{y}	1.10^{x}	17.1
	C2	.35^{x}	.32^{x}	.37^{x}	.36^{x}	.51^{y}	18.6
	C3	.55	.55	.60	.58	.64	12.9
	C4	.68	.71	.74	.78	.75	12.9
ADFI, lb./day	1	.34^{x}	.26^{x}	.26^{x}	.32^{x}	.49^{y}	21.4
	2	.77^{x}	.73^{x}	.74^{x}	.81^{x}	1.04^{y}	14.8
	3	1.52^{xy}	1.68^{y}	1.60^{y}	1.69^{y}	1.40^{x}	9.6
	4	1.91	2.13	2.07	2.30	1.96	14.8
	C2	.55^{x}	.49^{x}	.50^{x}	.56^{x}	.76^{y}	15.1
	C3	.86	.85	.87	.91	.98	10.3
	C4	1.12	1.15	1.17	1.25	1.23	11.0
G/F	1	.286^{xy}	.232^{x}	.450^{y}	.401^{xy}	.622^{z}	36.1
	2	.789	.799	.819	.750	.687	15.8
	3	.642	.641	.654	.625	.635	12.6
	4	.560	.585	.569	.609	.552	9.4
	C2	.636	.641	.729	.660	.663	12.7
	C3	.639	.644	.683	.640	.650	7.9
	C4	.606	.617	.633	.626	.610	6.2
Diarrhea scored		1.97^{x}	2.23^{x}	2.01^{x}	2.06^{x}	1.53^{y}	10.3

[a]Initial weight 13.9 lb.; final weight 34.3 lb.. There were five pens of pigs for treatments 1-4 and four pens for treatment 5. In three blocks, pens contained five pigs and in two blocks, pens contained four pigs.
[b]Refer to Table 3 for treatment description.
[c]C2, C3, and C4 indicate cumulative two-, three-, and four-week responses, respectively.
[xyz]Treatments without common superscripts differ P<.05.

Table 7. Growth performance – experiment 4.[a]

Item	Week[c]	Treatment no.[b] 1 DW	2 IT2	3 IT4	Probability 1 vs. 2 & 3	2 vs. 3	CV
ADG, lb./day	1	.20	.23	.16	.90	.02	27.0
	2	.69	.69	.70	.92	.93	17.8
	3	1.10	1.31	1.28	.05	.77	16.1
	4	1.34	1.41	1.52	.07	.18	10.0
	C2	.44	.46	.43	.97	.39	17.1
	C3	.66	.75	.71	.06	.37	9.8
	C4	.83	.91	.91	.01	.97	6.8
ADFI, lb./day	1	.45	.41	.34	.08	.12	20.5
	2	.94	.99	.95	.57	.55	10.3
	3	1.64	1.92	1.76	.01	.05	8.2
	4	2.17	2.39	2.45	.02	.57	8.6
	C2	.70	.70	.65	.53	.24	11.7
	C3	.01	1.11	1.02	.16	.04	7.0
	C4	1.30	1.43	1.38	.008	.17	4.9
G/F	1	.442	.561	.454	.16	.06	19.7
	2	.726	.699	.732	.82	.53	13.4
	3	.668	.682	.724	.35	.32	11.1
	4	.616	.594	.621	.62	.15	5.6
	C2	.634	.657	.660	.49	.94	11.1
	C3	.656	.672	.698	.18	.30	6.6
	C4	.639	.639	.664	.26	.08	3.6

[a]Initial weight 13.8 lb.; final weight 38.6 lb.; each value is the mean of seven pens each containing four pigs.
[b]DW=dried whey control; IT2=intestinal hydrolysate for two weeks; IT4=hydrolysate for four weeks.
[c]C2, C3, and C4 indicate cumulative two-, three-, and four-week responses, respectively.